Instruction Manual

The "Small Wonder- 40+"

40 Meter Superhet Transceiver Kit

© Copyright 1998, D. Benson. No portion of this document may be reproduced without the express written consent of the author.

Thanks! for purchasing one of the ***Small Wonder Labs*** "SW-40+" transceiver kits. This kit is an updated version of the classic '40-40' transceiver board which originally appeared in the November '94 issue of QST.

Please take a few moments to look over the section entitled "**First Things First**". This is background information in case you're fairly new to homebrewing or kit-building.

Please- Be sure to read through the "**Building instructions**" portion of this manual before you fire that soldering iron up! That section contains useful information which is key to your success with this kit. Kindly take a few moments to look this material over.

TABLE OF CONTENTS

First Things First.....	2
Materials	3
Parts List	4
Theory of Operation	6
Schematic	8
Pictorial Drawings.....	9
Building instructions	11
Wiring the "SW-40+"	14
Alignment	16
Troubleshooting the "SW-40+"	17
Troubleshooting values	19
Printed-circuit Layout	20

SW-40+ Manual Errata

1) Parts list, page 4- "C2-15" should read "C12-15"

2) Pictorial illustration on page 9, R29 (PA base swamping resistor) should be 51 ohms (per schematic and parts list) rather than the 100-ohm value illustrated.

as of 4/13/98

• THE FINE PRINT:

There are lots of small parts in this kit. With many of us getting older, this may prove troublesome. I highly recommend a magnifying glass or close-up glasses to check all solder joints and component codes.

• THE OTHER FINE PRINT:

Despite the care I've put into this manual, it may contain the occasional error. In the event of a conflict between portions of this manual, the following order of precedence applies (most trustworthy first):

- Schematic
- Pictorial
- Parts list
- Everything else

By all means, let me know when you catch these- I do appreciate hearing about them. I add corrective changes immediately because it improves the product!

☞Documentation updates are posted on the internet. See http://reality.sgi.com/adams, look under 'Elmer101'. If you don't have Web access, contact me by e-mail <bensondj @aol.com>.

TOOLS

You'll need the following tools:

-Soldering iron- 25-40W, solder
-Diagonal cutters
-Needle-nose pliers (helpful)
-Small slot screwdriver
- Magnifying glass (recommended)

TEST EQUIPMENT

You'll need the following:

- DC power source- 12-14V @ 500 mA min.
- Multimeter
- Another transceiver (for final adjustment)

The following are helpful but not essential:

- Frequency Counter

First Things First - what you should know:

You don't need to be an expert in all phases of this craft, but you should be comfortable with the basics before you embark on this adventure.

• *COLOR CODES:*

You should be familiar with the standard color-code markings on resistors. If not, Radio Shack's Color-Code Guide, #271-1210, will help. If you're not sure, verify the resistor values with an ohm meter. Resistor color codes are given in the parts list.

☞ For what it's worth, approximately 8% of the male population is red/green color blind. If you're one of these, you should be verifying all resistors with a meter before installing them.

☞ The SW-40+ board is double-sided and all holes on the board are plated-through. This means that you **do not** need to solder on the top side of the board.

• *SOLDERING SKILLS*

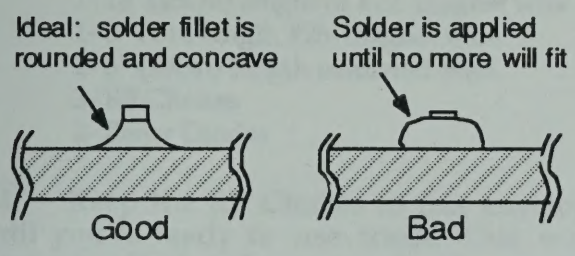
Hopefully this isn't your first experience with a soldering iron. If it is, though, or this is your first solid-state project, here are some tips to ensure your success:

- Soldering Iron:

Use a small iron in the 25-watt class (such as a Radio Shack #64-2070) and keep the tip clean. Use a moistened sponge or paper towel to clean the tip periodically as you work.

• Touch the soldering iron tip to the PC board trace and the component lead simultaneously. Within a second or two, apply solder and you'll see the solder flow onto the junction. Withdraw the solder and then the soldering iron.

• Avoid the temptation to load solder onto the joint until no more will fit! This is an invitation for trouble, as solder bridges may form across the closer trace separations. Here's what the correct and incorrect joint treatments look like:



PLEASE READ THE SECTION BELOW BEFORE REMOVING ANY PARTS FROM THE PC BOARD.

Uh-oh! Sooner or later, you may need to remove a part installed in the wrong location, or perhaps pull a component for troubleshooting purposes.

☞ Get yourself a roll of desoldering braid (Radio Shack #64-2090B). Lay the end of the braid down on the joint to be cleaned and press the soldering iron tip over the braid. Within several seconds you'll see the braid begin to wick up solder from the joint. Remove the braid and reapply a new section as needed until the joint is clean. It may be necessary to pull the component out from the top side of the board while heating the joint. Leave the iron tip on the board only as long as necessary to do the job- the PC-board traces will eventually delaminate (peel off) if overheated.

If that still doesn't do the trick, it may be necessary to cut the offending part off on the top side and pull the remaining leads through with pliers. Contact me for replacement parts if necessary.

☞ If you need to remove a transistor I'd highly recommend sacrificing the part by snipping it off on the top side of the board. The TO-92 pads in particular are small and the leads are best pulled out independently to minimize the risk of lifting pads.

☞ After removing a component from the board, the through-hole will probably still be blocked with solder. Use a dissecting needle, dental probe (explorer) or even a large sewing needle, applying heat to the needle and board trace simultaneously until the tool pushes through.

WINDING TOROIDS:

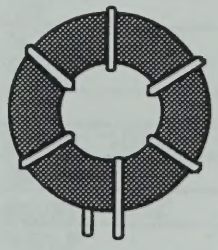
-Count as you go. Draw each turn snug against the core to ensure a trim and tight winding. Please ensure that none of the turns is wound "over" (on top of) its neighbors.

-Doublecheck the turns count when you're finished. Use your fingernail or small screwdriver to "bump" over each turn as you count- this is much easier than counting by eye.

- Trim the excess wire off to about 1/4" and strip the insulation off with a hobby knife.

Counting the turns:

☞ If the wire passes through the toroid center hole, it counts as a turn.



This toroid is wound with 6 turns.

• Turns must be uniformly distributed around the circumference of the toroid.

Materials-

You'll find the following items with your SW-40 + kit:

1- bag of small parts (resistors, caps, etc)
1- antistatic bag (contains semiconductors)
1- envelope labeled "MISCELLANEOUS"
1- printed circuit board
- (this manual)

The "Miscellaneous" envelope contains the following items:

1- 18" (45cm) length of #22 magnet wire
1- 3' (1m) length #26 magnet wire
1- 6" (15cm) length insulated wire
3- RF Chokes
2- Zener Diodes

☞ Keep the RF Chokes in this envelope until you're ready to use them. This way, they're less likely to be confused with resistors.

• **(You may want to reproduce the schematic and layout pages so you can mark on them as you work**, and still keep the original neat and clean.)

Reference designators:

Each component is uniquely identified by a reference designator. Bypass capacitors are identified as C100 and up.

"C7":

Capacitor C7 is a assortment of 6 different capacitors designated C7A through C7F, it replaces a trimmer cap found on the original SW-40. Selection and installation of this cap is described later in the text.

Monolithic caps:

The printing on these parts is tiny! I'd highly recommend using a magnifying glass to verify component values before installing them.

• **IF Transformers:**

Although not illustrated on the schematic drawing for reasons of drawing clarity, T1-T3 contain internal capacitors. Do not remove these capacitors.

Special Parts Notes:

Parts List- "SW-40+" Transceiver

Qty	Ref. Desig.	Description	Identification
2	C3,C9	10 pF ceramic disk	'10'
1	C7A	22 pF NPO cer. disk	'22'
10	C1,2,7B,11,17,18,28,30,32,40	47 pF NPO cer. disk	'47'
2	C7C,16	68 pF NPO cer. disk	'68'
2	C7D,C8	82 pF NPO cer. disk	'82'
1	C7E	100 pF NPO mono. cap	epoxy, '101J'
1	C7F	120 pF NPO mono. cap	epoxy, '121J'
1	C7G	150 pF NPO mono. cap	epoxy, '151J'
7	C2-15,22,23,29	150 pF ceramic disk	'151J'
1	C31	220 pF ceramic disk	'221J'
1	C10	270 pF ceramic disk	'271J'
2	C37,39	470 pF ceramic disk	'471J'
1	C25	820 pF ceramic disk	'821J'
1	C38	1000 pF NPO mono. cap	epoxy, '102J'
2	C4,5	2700 pF NPO mono. cap	epoxy, '272J'
1	C6	3300 pF NPO mono. cap	epoxy, '332J'

Parts List- (cont'd)

Qty	Ref. Desig.	Description	Identification
1	C26	.0022 uF ceramic disk	"222J"
11	C21,33-35,102-105, 108,109,111	.01 uF ceramic cisk	"103M"
1	C19	.033 uF ceramic disk	"333M" or "333Z"
7	C20,24,36,101,107,113,114	0.1 uF monolithic cap	epoxy, "104"
1	C110	3.3 uF 50V radial Elec. Cap	*banded end is negative*
2	C27,106	47 uF 16 V radial Elec. Cap	" " " "
1	C112	220 uF 16V radial Elec. Cap	" " " "
1	D1	MV1662 Varicap diode	TO-92, 2 leads, stripes only
9	D2-10	1N4148A diode	glass body
1	D11	7.5V 0.5W 5% Zener Diode	1N5236
1	D12	33 V 0.5W 5% Zener Diode	1N5257
1	D13	1N4001 diode	red case
1	L1	T-50-6, *see text, p. 12*	0.50" dia, yellow
1	L2	FT37-43, 6 turns	0.37" dia, dark grey
2	L3, L4	T-37-2, 1.0 uH, 16T #26	0.37" dia., red
1	Q1	MPF102	plastic-cased (TO-92)
1	Q3	2N3906	plastic-cased (TO-92)
3	Q2,Q4, Q5	2N4401	plastic-cased (TO-92)
1	Q6	2SC2078	TO-220 device
2	RFC1,RFC2	22 uH 5% RF Choke	Red-Red-Black-Gold
1	RFC3	10uH 5% RF Choke	Brwn-Blk-Blk-Gold
1	R24	500Ω trim pot	White plastic, 3 leads
3	R6,14,27	10Ω 1/4W 5% resistor	Brn-Blk-Blk-Gold
2	R28,29	51Ω 1/4W 5% resistor	Green-Brown-Blk-Gold
2	R1,26	470Ω 1/4W 5% resistor	Yellow-Viol.-Brn-Gold
1	R19	1KΩ 1/4W 5% resistor	Brn-Blk-Red-Gold
2	R17,25	2.2KΩ 1/4W 5% resistor	Red-Red-Red-Gold
4	R2,3,21,22	10KΩ 1/4W 5% resistor	Brn-Blk-Orange-Gold
4	R10,16,20,23	22KΩ 1/4W 5% resistor	Red-Red-Orange-Gold
1	R15	47KΩ 1/4W 5% resistor	Yellow-Viol.-Orange-Gold
3	R4,7,11	510KΩ 1/4W 5% resistor	Green-Brown-Yellow-Gold
4	R8,12,13,18	1MΩ 1/4W 5% resistor	Brn-Blk-Green-Gold
1	R9	4.7MΩ 1/4W 5% resistor	Yellow-Viol.-Green-Gold
4	S1-S4	8-pin low-profile IC socket	
3	T1-T3	10.7 Mhz IF transformer	"42IF123"
1	T4	FT37-43, 8T:1T,*see text*	0.37" dia., dark grey
1	U2	78L08 voltage regulator	plastic-cased (TO-92)
3	U1,U3,U5	NE602AN, NE612AN, SA602AN or SA612AN	8-pin IC
1	U4	NE5532	8-pin IC
5	Y1-Y5	4.00 Mhz HC-18/U Xtal, 20pF	*(may be house # marked)*

Theory of operation

This transceiver is a single PC-board design measuring 2.8" x 4.0" (7 x 10 cm). It features VFO operation with a 35-40 Khz tuning range, as well as QSK (full break-in) operation. Let's take the 50-cent tour:

The receiver RF input is applied to U1 through T1 and C1, which provide a bandpass filter tuned to 7.0 Mhz. T1's secondary winding provides roughly unity- gain into U1 to minimize overload (IMD). U1 provides about 13 dB of gain in this configuration, and converts the RF input to the IF frequency of 4.0 Mhz. The L-network (C11 and RFC1) following the mixer serve to step the mixer output impedance down to the crystal filter's design value. *Note that C12 and RFC1 appear to be 'transposed' , this reflects the board's physical layout.*

The crystal filter itself uses 3 crystals. This works well because of the choice of a low IF frequency. Loss through the filter is less than 2 dB, and with the component values shown, the -6dB bandwidth is about 500 Hz. Despite the filter's low parts count, performance is adequate when combined with the AF section's selectivity. The unwanted sideband image is down about 50 dB at the audio chain's 800 Hz peak response frequency.

The filter output is terminated in a 470Ω resistor at the input to U3, the product detector stage. U3 converts the 4.0 Mhz IF signal to audio and contributes another 13 dB of gain. BFO crystal Y3 has been selected to match the IF filter frequency, so there's no BFO frequency trimming needed. The .033 uF capacitor across pins 4 and 5 of U3 provides the first measure of audio low-pass filtering.

The two sections of U4 each provide roughly 30 dB of amplification. The first section is configured as a differential amplifier to make use of U3's differential output and rolls off the audio response above 1.5 khz. Diodes D3 and D4 serve to limit the audio swing during transmitter key-down to reasonable values. Without these diodes, this stage saturates and upsets the operation of the following FET switch section.

The AF mute function is the familiar series FET switch popularized by W7EL. Despite its relative simplicity, it's hard to beat this circuit for click-free audio switching. In the "key-up" condition the FET is "zero-biased" and acts like a resistance of several hundred ohms. In the "key-down" condition the FET is in cutoff (because the gate is now 7-8 volts below the source) and acts like an open-circuit, preventing audio from getting to U4B, the audio final stage. This stage is configured as a bandpass filter centered at 800 Hz. The high gain of the two NE5532 stages (64 dB total) allows a design with no IF amp stage. The audio output level is adequate to drive headphones, but it won't do the job for loudspeaker applications. The AF output stage internally overcurrent-limits on loud signals to provide a ready-made ear protection function. (In this respect, it accomplishes what you'd want an AGC for anyway.) If you're interested in saving at least 5 milliamps on receive, U4 may be replaced by an LMC662 (available from Digikey). This suggestion is courtesy of Mitch Lee and Dennis Monticelli, from their excellent article, "Revisiting the 40-40" in the ARRL's 'QRP Power".) *Use good quality low-impedance headphones for best results. "Walk-man"-headphones are fine, but remember- you get what you pay for- the 3-dollar bargains are distinctly inferior!*

QSK: The T-R switch function is provided by C40 and RFC3, which form a series-resonant circuit. Diodes D7-D10 limit during key-down and thereby restrict the signal levels presented to the receiver front-end during transmit. *The doube-diode configuration raises the network's intercept point with respect to W7EL's original configuration to improve IMD immunity.*

The LO uses the Colpitts configuration. The frequency-determining capacitors are NPO (C0G) monolithic types. These devices are extremely compact and offer good temperature stability. C2 and C3 are a voltage divider providing proper injection to U1, *Note: If you want broader frequency coverage, the value of C8 may be increased. The useful upper limit for C8 is about 1000 pF, and especially at the larger values, capacitor (and varicap diode D1) thermal stability will become crucial. Use NPO /C0G capacitors if possible if you tinker with this circuit.*

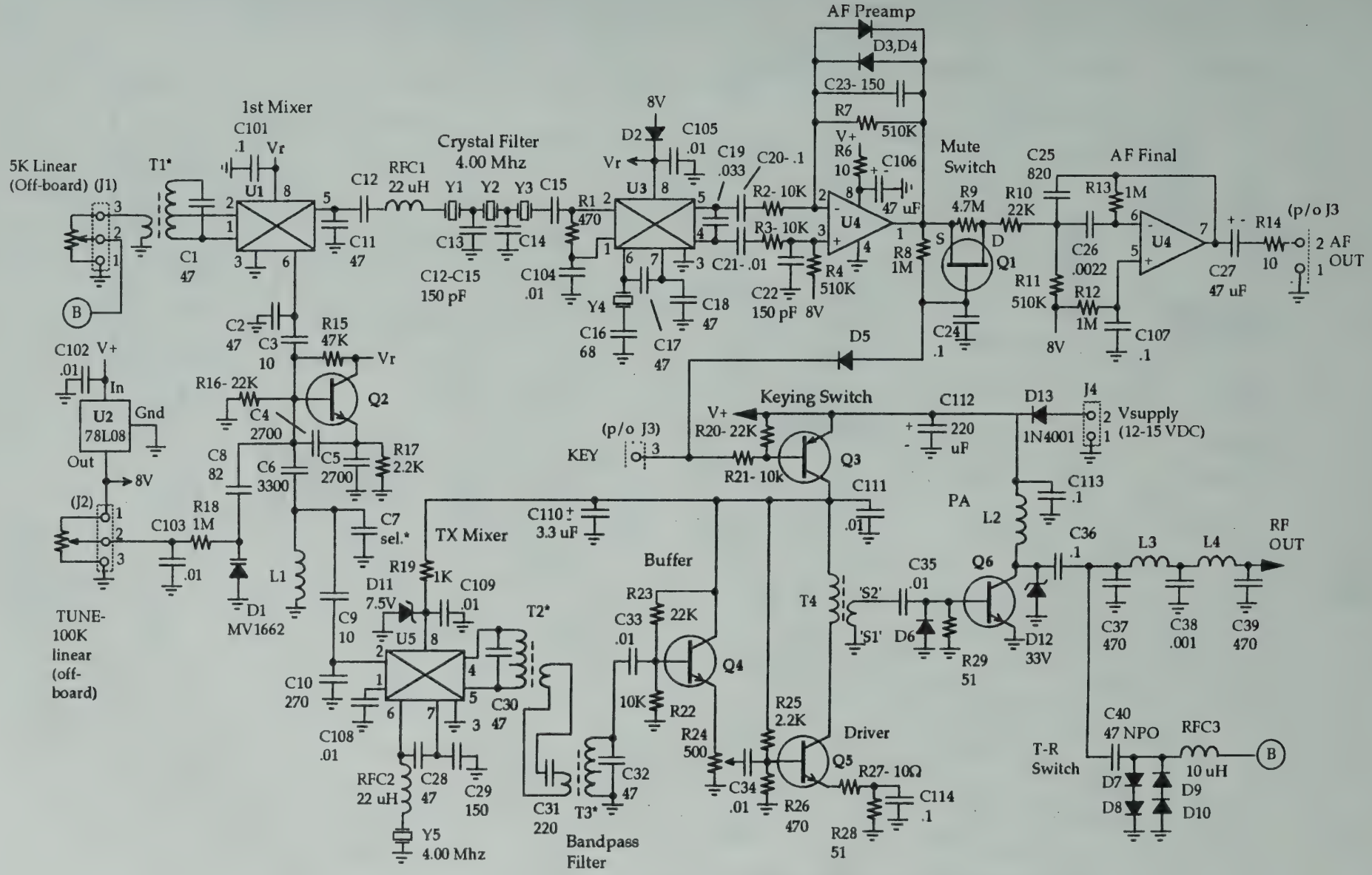
The design also uses a varicap tuning diode for tuning coverage. While a smooth ball-bearing tuning cap and vernier reduction drive are the preferred approach, that choice drives the cost and mechanical complexity of a transceiver up considerably. The varicap approach supports quite a compact package! If you've just got to have RIT, an outboard circuit which injects an adjustable DC offset into the diode bias network on receive does the trick.

The transmitter chain is a pretty standard affair. The maximum output power is about 2-2.5 watts and there's a drive control at the emitter follower stage (Q4) to adjust the output level. The diode the base of Q6 serves to 'clamp' the signal to Q6 above ground and thus improves drive to the PA by several dB. *I don't feel that the PA requires a heat sink at the 1.5-2.5W power level and CW duty cycles. If you like, there's room for a 'compact'-style T0-220 heat sink (Digikey #HS-105 or HS-106).*

This rig complies with the FCC requirements for spurious emissions. All harmonics were down at least 34 dB. The largest spurious output was down at least 46 dB.

Here's a summary of the changes incorporated in this version of the SW-40:

- Added power supply reverse-polarity diode.
- The receiver front end is reworked to eliminate the original multiple-winding toroid.
- The diode bridge T-R switch is replaced by a series L-C type. This drops resting power supply current from 22 to 16 mA and significantly improves image rejection.
- The crystal filter grew from 2 to 3 crystals and changed to a Cohn filter configuration. A grounding point for the crystal cases is also provided to reduce filter 'blow-by'.
- Eliminated LO trimmer capacitor and replaced with pads for select assortment. Replaced polystyrene caps with C0G monolithic caps for improved reliability.
- Changed the TX bandpass filter to use IF transformers. This configuration makes use of the differential outputs of the NE612. Filter bandwidth is increased considerable over the original configuration.
- The PA is a T0-220 device, capable of considerably more output power than the original. This change was made to eliminate the TO-5/TO-39 device packaging, which is becoming increasingly difficult to find.
- Improved functional grouping of interconnect. The companion enclosure kit provides locking .100" headers, with pre-assembled harnesses.

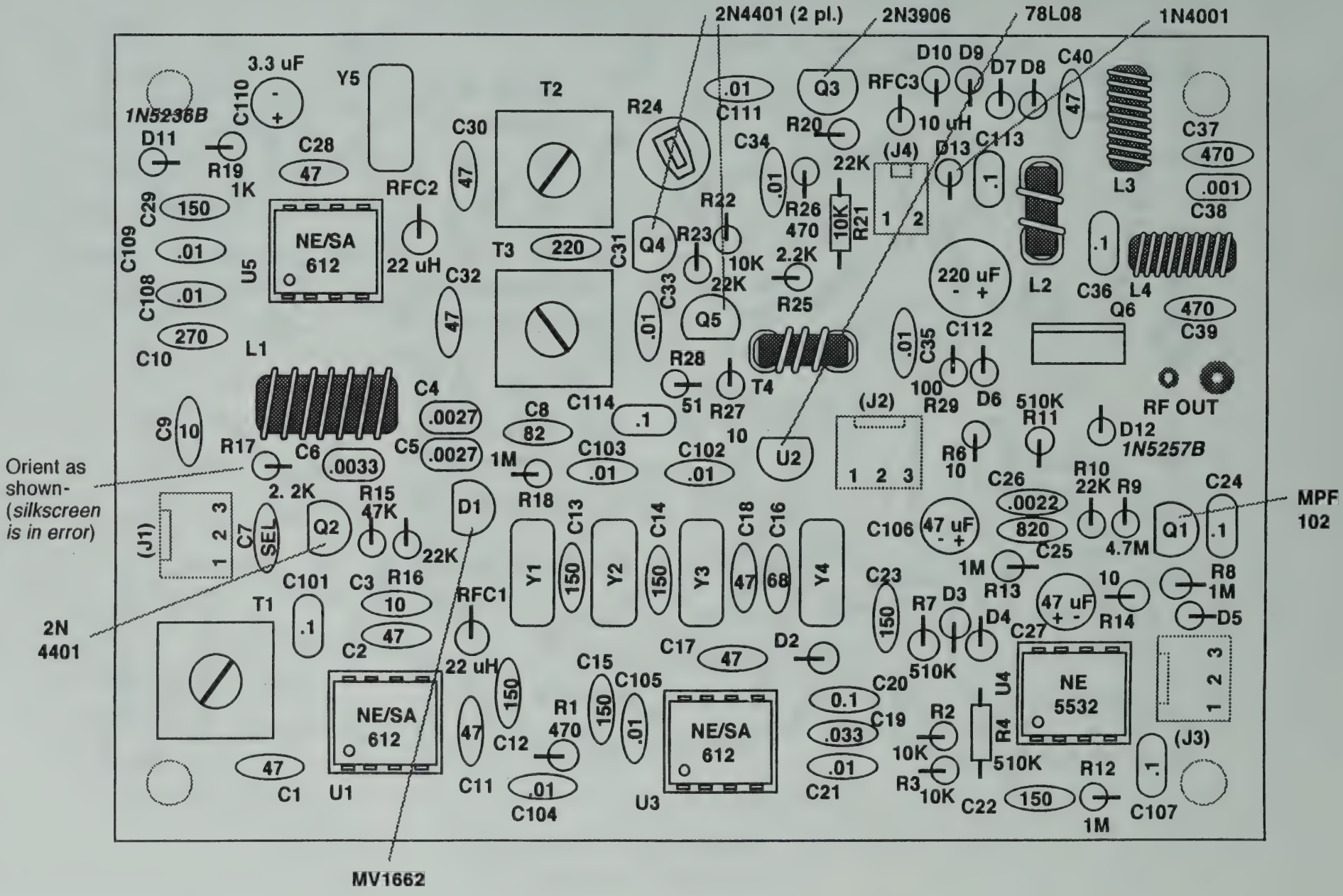


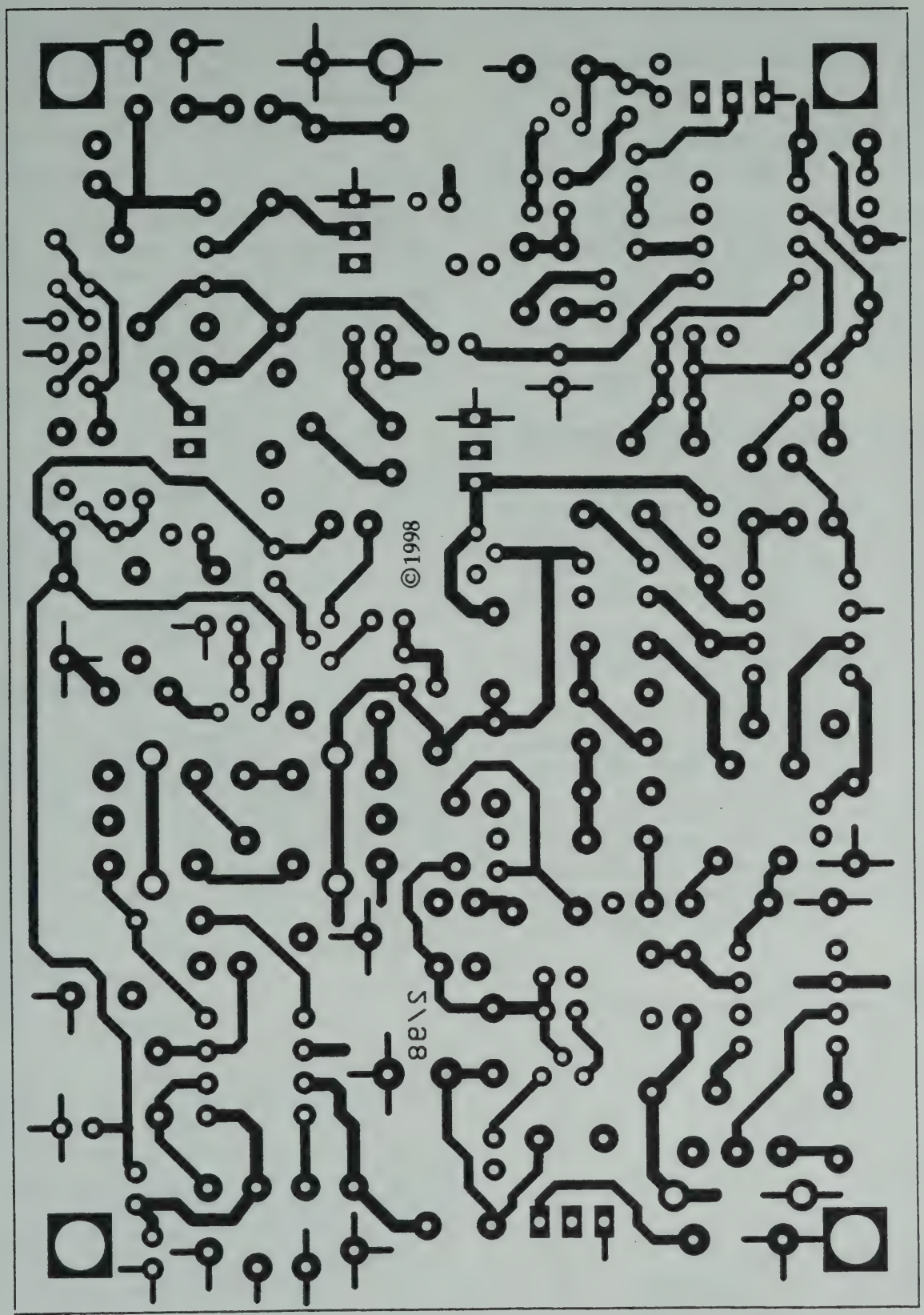
The "SW-40+" Transceiver

SMALL WONDER LABS™

3/18/98

* T1-T3
C-internal not shown,
leave intact.


2N4401 (2 pl.)
2N3906
78L08
1N4001
3.3 uF
1N5236B
D11
R19
1K
C110
C28
47
Y5
RFC2
22 uH
C30
47
T2
R24
C111
.01
Q3
RFC3
10 uH
D10 D9
D7 D8
C40
47
C37
470
.001
C38
L3
C34
.01
R20
22K
R26
470
(J4)
1 2
10K
R21
D13
C113
.1
R22
R23
10K
22K
R25
2.2K
T3
220
C31
Q4
Q5
C33
.01
C32
47
U5
NE/SA
612
C109
C29
150
.01
C108
.01
270
C10
L1
220 uF
L2
C36
.1
L4
Q6
470
C39
C35
.01
C112
100
D6
R28
51
R27
T4
U2
C114
.1
C8
82
C4
.0027
C5
.0027
C9
10
R17
2. 2K
C6
.0033
1M
C103
.01
C102
.01
(J2)
1 2 3
R29
10
510K
R11
D12
1N5257B
RF OUT
R6
10
C26
.0022
820
C25
R10
22K
R9
4.7M
C24
.1
Q1
MPF
102
C106
47 uF
1M
R13
10
R14
R8
1M
D5
Orient as
shown-
(silkscreen
is in error)
(J1)
1 2 3
C7
SEL
Q2
R15
47K
22K
R16
10
C3
47
C2
C101
.1
T1
2N
4401
RFC1
22 uF
Y1
150
Y2
150
Y3
47
68
Y4
C13
C14
C18
C16
C23
150
R7
510K
D3
D4
C27
C17
47
D2
C20
0.1
C19
.033
R2
10K
R3
10K
C21
.01
R4
510K
U4
NE
5532
C22
150
R12
1M
C107
.1
(J3)
1 2 3
C15
150
C105
.01
R1
470
C12
150
47
C11
.01
C104
C1
47
U1
NE/SA
612
U3
NE/SA
612
MV1662



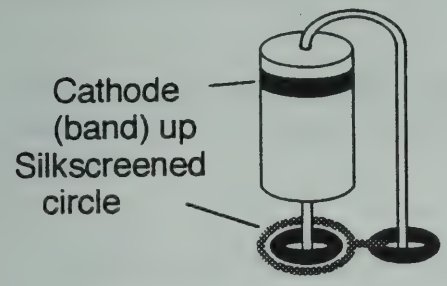
top (component) side PC layout
note: copper plane not shown

Building instructions:

• All parts installed on the PC board should be fully seated. Do not install the parts in "flying-lead" fashion in the hope that it will improve something-or-other! Minimum lead length is important to a successful RF design.

Diode Installation:

All diodes except D1 are bent for "upright" installation on the board. Installation polarity is as shown below. Be sure to note the orientation of the silkscreened circle on the board and install the diode body over this hole. The cathode (banded) end of the diode is oriented at the top.



• **Resistor installation:**

All resistors except R4 and R21 are likewise installed in 'hairpin' fashion. As with the diodes, try to match the mounting orientation shown on the drawing. (This usually has nothing to do with critical dimensions- if mounted as shown you've got better troubleshooting access to circuit points from the top side of the board.) Orientation of resistor (and other nonpolar device) color bands is non-critical.

Installing IC sockets:

The "notch" or dot at one end should be oriented as shown in the pictorial drawings. *Doublecheck orientation before soldering. A suggestion- solder down two opposite corners of each socket, and then go back and press a fingertip on the socket from underneath while reheating both connections in turn. You may then solder the remaining pads. This precaution ensures that the socket is well-seated on the PC board.*

Some additional tips:

• *It's helpful to work from one end or corner of the board to the other. This minimizes the "tight squeeze" cases where the last part in a cluster has to drop into a tight space.*

• *Stuff only a few parts at a time (3-4 pieces). If you try to add too many parts at once between soldering operations, you may lose track and wind up with missing solder joints! Once you've stuffed the parts on the board, bend the protruding leads slightly outward to keep them in place while the board is inverted for soldering.*

• *Some of the disk and monolithic capacitors may be supplied with a lead spacing of 0.10" (2.5mm). The "SW-40+" has generally been laid out for a 0.20" capacitor spacing. The capacitor leads may be gently spread apart near the component bodies and then bent parallel to ease installation.*

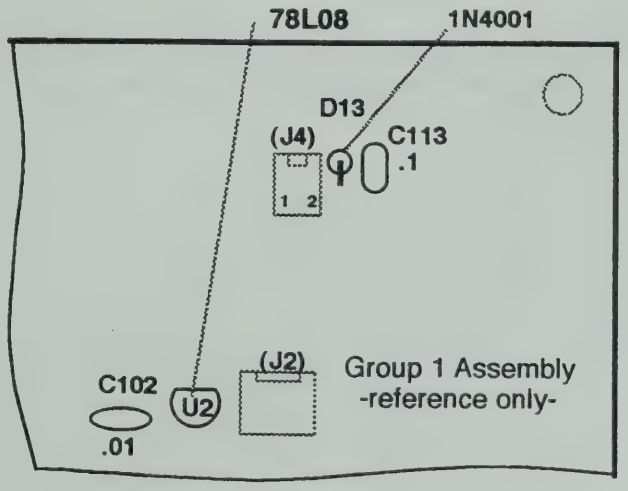
Recommended Assembly sequence:

I've specified the sequence below, but there's nothing sacred about the order in which the board is populated. Some parts are best installed in a particular order, as noted within each group's instructions.

• Directions for winding toroids are found within each group's assembly instructions.

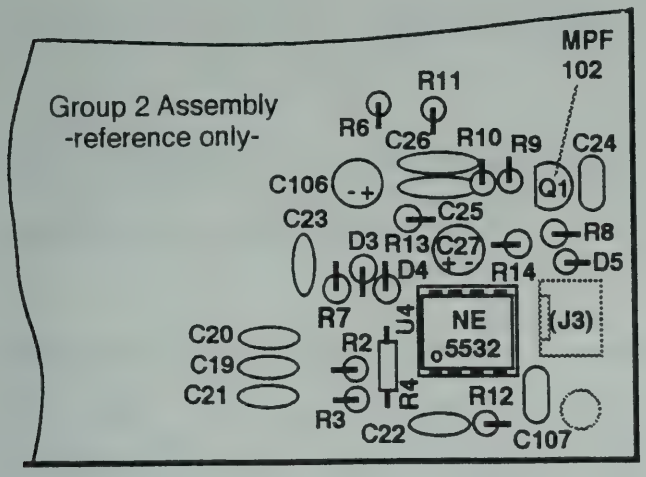
(The figures which follow are for reference only. **See the pictorial drawing on p. 9 for component values.**)

[ ] Install D13, U2 , C102 and C113. *If you have the companion enclosure kit, install connectors J4 (2-pin) and J2 (3-pin) as well. This step supplies DC power to the board and installs the 8 Volt regulator IC.*



[ ] Install an 8-pin IC socket at U4.

[ ] Install the components shown below:

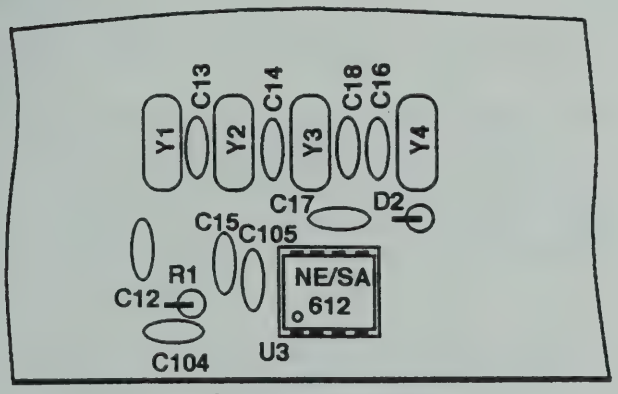


(When these components have been installed, the audio amplifier section of the transceiver is complete.)

[ ] Install an 8-pin IC socket at U3.

[ ] Install the components shown below:

Note: the 5 crystals supplied with this kit have been preselected as a group. They are interchangeable within this group. Do not, however, substitute replacement parts- contact me for assistance.



Group 3 Assembly
-reference only-

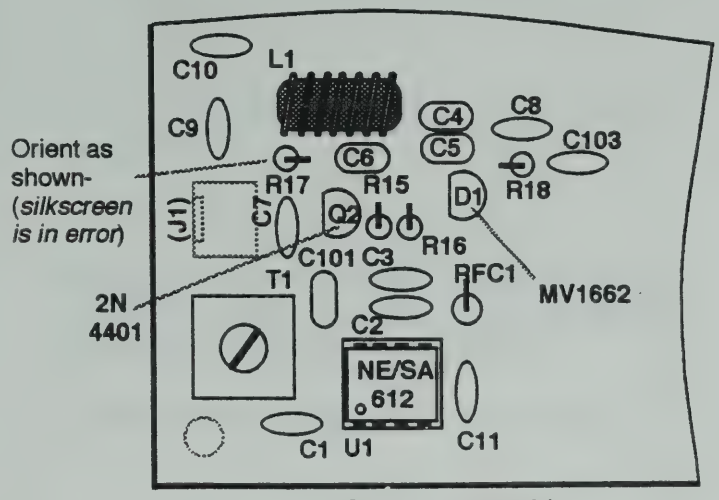
(When these components have been installed, the product detector/BFO and crystal filter sections of the transceiver are complete.)

[ ] Install an 8-pin IC socket at U1.

Install the components shown below:

- L1 (yellow core) is wound using the larger-diameter magnet wire from the "Misc" envelope. Wind with 25 turns (**24 turns for Novice-band operation**), prepare lead ends and install on the board. All other toroids use the smaller diameter wire.

☞ C7 is not installed at this time, see "Alignment" for installation procedure.



Group 4 assembly
-reference only-

(When these components have been installed, the receiver portion of the transceiver is complete.)

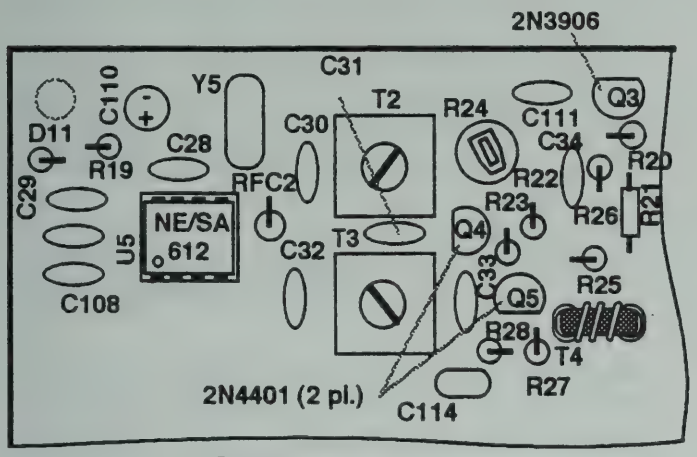
[ ] Install an 8-pin IC socket at U5.

[ ] Install the components shown below:

The following components are polarity-sensitive:

D11, C110, Q3-Q5

☞ Spacing on C31 (between transformers T2 and T3) is quite tight- install this capacitor prior to installing T2 and T3.



Group 5 assembly
-reference only-

• Tranformer T4 (grey core) is wound with 4" (10 cm) of magnet wire for the primary winding. The primary winding is wound first, using 8 turns. Install T4.

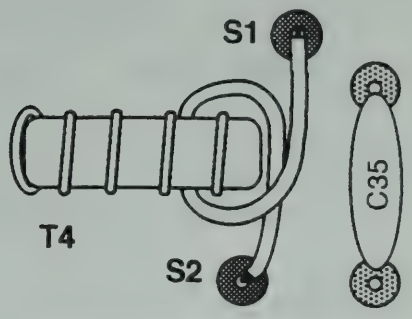
[ ]Add a secondary winding to T4 as follows:

1) Strip 1/8" of insulation from one end of the 3" length of insulated wire. Twist the wire gently between your fingertips to ensure that all strands are bundled together. Tin this lead-end with solder.

2) Install this lead-end in S2 and solder.

3) Take the free end of this wire in the direction of S1 and then double it back through the hole in T4.

4) Draw the lead snug (not tight!) and proceed around the toroid material until you've formed one complete turn through the toroid as shown below:



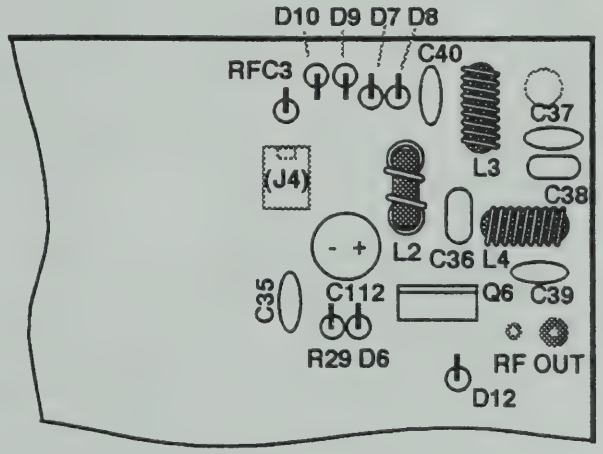
detail- T4 secondary winding

5) Trim off the free end of the wire so that it has about 1/4" (6mm) more than is needed to reach pad S1. Repeat the lead preparation as in step 1 above.

6) Install this lead-end in S1 and solder.

(When these components have been installed, the transmitter mixer, bandpass filter and driver sections of the transceiver are complete.)

[ ] Install the components shown below



Group 6 assembly
-reference only-

The following components are polarity-sensitive:

C112, D6-D10, D12, Q6

☞ Q6 (2SC2078) is installed with the metal tab to the rear (or 'top', when viewed from directly overhead). When viewing the board from the front edge (U1, U3 and U4 nearest you), Q6's labeling must be viewable

• L2 is wound using 4" (10 cm) of wire on an FT37-43 (grey) core. Wind 6 turns on this core, prepare lead ends and install on the board.

• L3 and L4 are each is wound using 10" (25 cm) of wire on an T37-2 (red) core. Wind each with 16 turns, prepare lead ends and install each of these on the board.

(When these components have been installed, the board assembly is complete.)

If you have not already done so, install all integrated circuits on the board as indicated on page 9. Be sure that the ICs are oriented properly - the dot or notch is on the left side of the 8-pin DIP ICs as viewed on the pictorial.

CLEAN UP YOUR ACT! Before you install the finished PC board into an enclosure, grab some cotton swabs and use acetone (nail polish remover) to remove solder flux from the foil-side of the PC board. The result is a much cleaner appearance once you've completed this step.

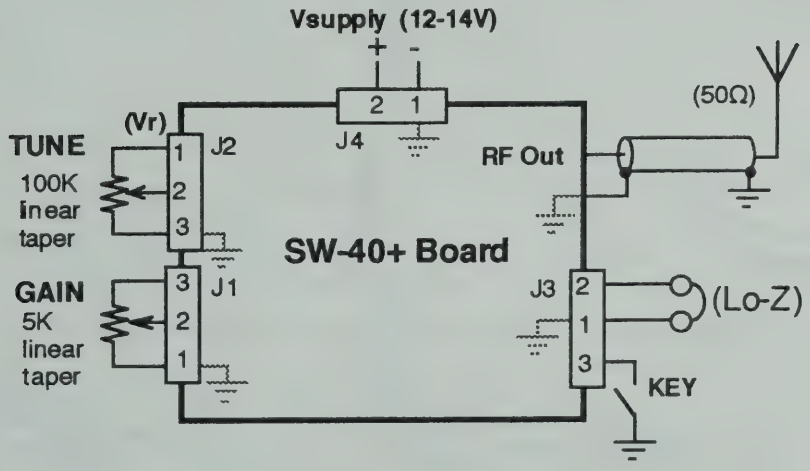
Wiring the SW-40+:

The figure below show the schematic interconnect between the SW-40+ board and the outside world(more on alignment later).

Short, direct leads between the "SW-40+" board and your connectors and controls are advisable. If you're going to run the RF output more than a couple of inches to an antenna jack, coax (such as the subminiature RG-174) is recommended. The other interconnect wiring is less critical, but try to avoid routing the wiring over the audio (U4) filter section if possible.

• The companion enclosure kit includes .100" header strips and mating connectors with pre-assembled harness. Install these if you have that kit. **(Contact me if you'd like further information on that kit.)**

• If you have just the board kit, proceed to wire directly to the 'J-series' locations.



Wire the connectors and controls to the SW-40+ as shown pictorially below. Note that the keying return line lacks its own distinct board connection. This return line is shared with the headphone's return.

STOP!

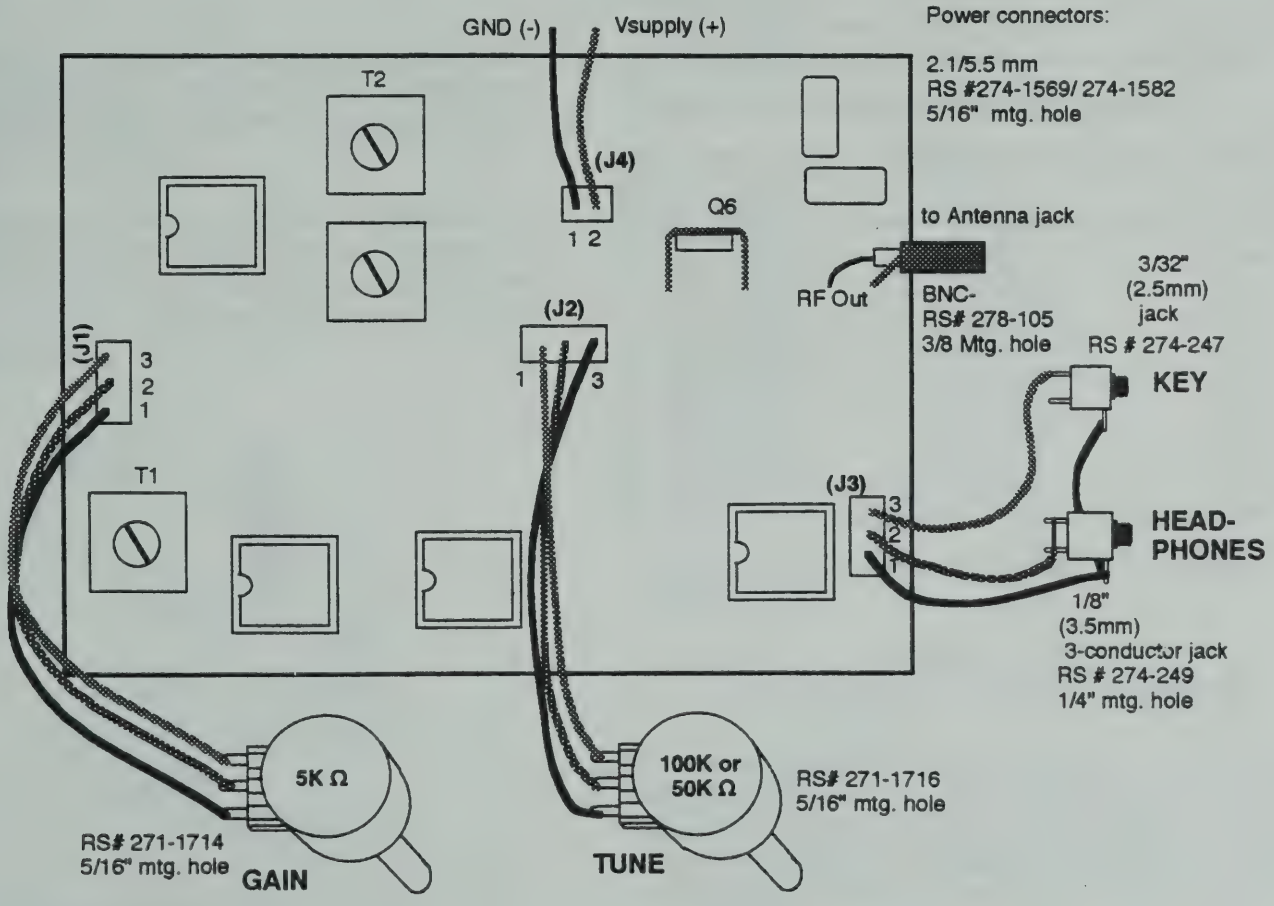
Before you progress to the next phase of this project, this might be a good time to check out the "SW-40"+. Add the various connectors and controls using temporary leads before you get the project buttoned up in a box. If you need to do any troubleshooting, you'll have saved the aggravation of having to undo all the wiring to get at the bottom side of the board!

"SW-40+" Mechanical Details

The pictorial figure below shows some ideas for connectors and their accompanying mounting hole diameters. These are merely suggestions and are a matter of personal preference.

The board itself is mounted in an enclosure at the board's four corners, using #4 machine screw hardware. #4 spacers should be used to separate the PC board from the enclosure by 3/16" or more. (#4 hex nuts are an acceptable substitute for spacers.)

Enclosures may be found in a variety of styles. Radio Shack offers several types of metallic enclosures. I'd especially recommend Hosfelt Electronics, Inc., who carry enclosures offered by a number of companies. There's no minimum order, and they can be reached at [800] 524-6464 for a catalog. Ten-Tec also offers a complete line of enclosures, and they support small orders as well! Call [800] 231-8842 for a free brochure.



Before the "Smoke Test":

• Inspect your work to ensure there are no solder bridges or unsoldered joints. Check to see that the ICs are mounted in their proper orientations.

Alignment:

Alignment is easy with this little rig. For test equipment, you'll need a main-station rig and multimeter or SWR bridge. Here's how:

Transmitter alignment:

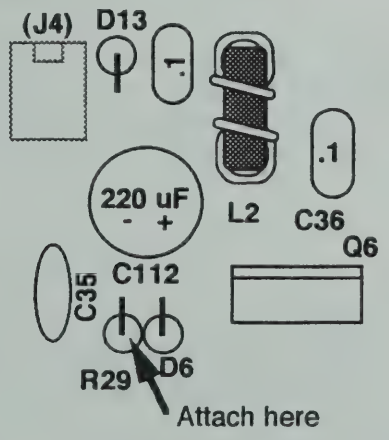
[ ] Connect a tuning pot to J2. (See page 13 for interconnect pictorial.) Set the tuning pot to full counterclockwise (0V on the pot's center terminal).

[ ] Connect a 50-ohm dummy load to 'RF Out' and its adjoining ground return pad.

[ ] Set trimmer R24 to the halfscale ('3 o'clock') position.

[ ] Using a small slot screwdrive, preset the tuning slugs in T2 and T3 to the middle of their rotation range. *(This is non-critical, there's no need to count turns!)*

[ ] Add a clip lead to R29 (see figure below) to serve as a short whip antenna. (Leave the other end of the clip lead unconnected, and ensure that this free end is well away from other circuitry.)



[ ] Apply DC power (J4)

[ ] Ground the "Key" (J3-3) input.

[ ] Tune in your transmitted signal on your "big rig" receiver. This should be a strong carrier (S9+20 or better).

☞ Be sure to hunt for the strongest signal over a range of 7.0 to 7.3 Mhz to ensure that you find the primary signal instead of a receiver spurious response.

Operating frequency adjustment:

[ ] Note the frequency from the step above. Remove power and install a value of C7 in accordance with one of the tables below:

• **For 7-7.05 Mhz operation:**

If the frequency was between:	Install the following value for C7
7000-7030	(none)
7030-7060	22 pF
7060-7090	47 pF
7090-7120	68 pF
7120-7140	82 pF
7140-7160	100 pF
7160-7180	120 pF
7180-7210	150 pF

• **For 7.1-7.15 Mhz (Novice) operation:**

If the frequency was between:	Install the following value for C7
7100-7130	(none)
7130-7160	22 pF
7160-7190	47 pF
7190-7220	68 pF
7220-7240	82 pF
7240-7260	100 pF
7260-7280	120 pF
7280-7310	150 pF

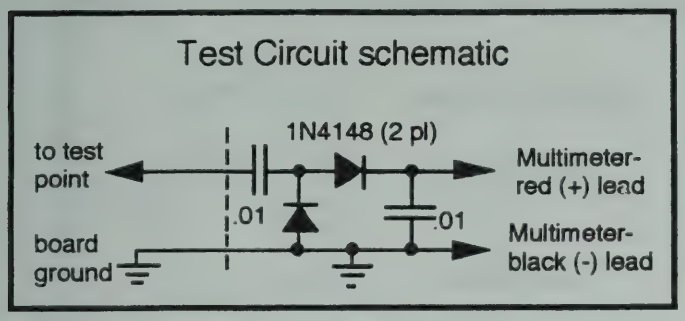
(The approximate formula for the value of C7 is as follows:)

[C7] (in pF) = Δf (khz) / 1.42
where Δf is the desired frequency shift.

☞ It's possible to adjust the operating frequency as much as 15-20 Khz downward by squeezing L1's turns more closely together. If in doubt which of two values of C7 to use, install the smaller of the two and compress L1's turns as needed.

Connect the RF output to a wattmeter (if you have one). You can also use your SWR meter with a dummy load connected and set in the "Forward" metering position.

If you don't have either of these pieces of equipment, you can 'haywire' the test circuit below on a scrap of copper clad board. This peak detector circuit furnishes a DC voltage to your multimeter.)



Adjust T2 and T3 for maximum indicated signal on your receiver's S-meter. The adjustment will be somewhat interactive, so alternate between the two for maximum output.

- (Remove the clip lead.) Adjust trimmer R24 as needed for 1.5 watts key-down power into a dummy load or the test circuit shown on the previous page. (*For the test circuit above, this corresponds to a DVM measurement of 12V DC*). Increase drive (R24 clockwise) only as needed to get to this level.

Receiver alignment:

- Connect a matched antenna to "RF Out" and its ground return. Using a small slot screwdriver, peak T1 for maximum signal (or noise). Once this step is complete, background noise should be noticeably higher with an antenna connected than without.

That's it - you're on the air!

Troubleshooting the "SW-40+":

The "bugs" you're most likely to encounter often turn out to be caused by the simplest of problems. If your "SW-40+" doesn't play, the following general suggestions may be helpful:

"It works better plugged in!"

We've all heard that expression before, but unfortunately it's true. Ensure that DC power is getting to the SW-40+. A board with no voltage anywhere probably isn't getting power.

"The headphones are silent!"

It's probably the same as above- an interconnect problem. The 1/8" (3.5mm) jacks in particular are trouble-prone.

• Check once more for solder bridges and missing solder joints. Probing a suspect section of the circuitry with a fingertip or insulated tool will sometimes bring a stubborn circuit to life- if so, check again for a bad connection!

Of the returns I see, about 85% of the problems are caused by cold solder joints, 5% by solder bridges and 5% due to incorrect resistor installation. That leaves only 5% for all the other problems put together! 'Nuff said.

• Ensure that the ICs are installed in the correct location and with the right orientation.

• Likewise ensure that the transistors and all diodes are installed with the correct orientation.

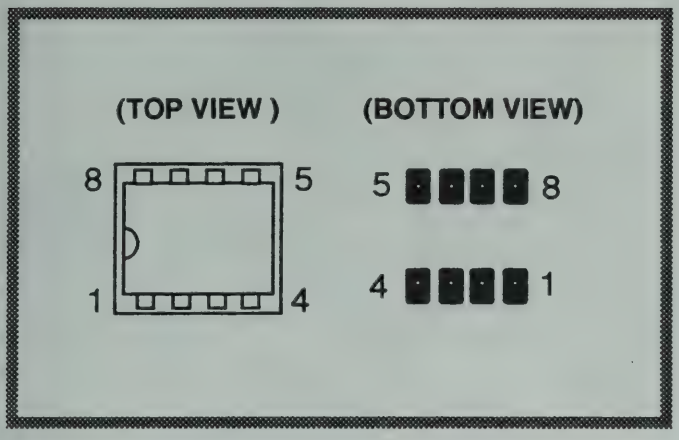
• If you don't turn up anything with the above steps, see the troubleshooting schematic on the last page of this manual. Using a DVM, check the circuit points noted on the drawing against your "SW-40+" to confirm that the DC voltage readings are all in order.

Here's a rule of thumb for the troubleshooting voltages: I've supplied the nominal voltage readings, but there's some unit-to-unit variation. As an overall guideline, a 20% variation is an

generally break just a little- you're looking for the obvious departures from the published values.

The troubleshooting schematic also lists AC voltage readings in case you have access to an oscilloscope or have a hi-impedance input RF probe. Readings are given in Volts p-p.

☞ The figure below illustrates IC pinout. *The "pin 1 at lower left" convention applies to all Dual-Inline-Package (DIP) ICs.*



"Strange but True"- *In general, the ICs themselves shouldn't be prime suspects during the troubleshooting process. Despite their complexity, they're very reliable, and I've had to replace these parts at the rate of only 1 for every thousand or so shipped!*

If those steps don't turn up something, here are some additional steps to try:

Receiver

• Touching either of the 10K resistor leads to the left of the AF Amp IC (U4) should cause an easily-audible hum or buzz in the headphones. If not, and Vr (the 8V supply) is OK, the NE5532 op amp (U4) is suspect.

• Touching an antenna wire to the 470Ω resistor to the left of U3 (product detector) should cause shortwave "crud" to be audible in the headphones. Also, a signal source such as your main station transmitter (on minimum power, please!) should provide a plainly audible signal when you transmit a string of CW characters just above or below the 4.000 Mhz IF frequency. Do not connect the main station transmitter to the "SW-40+"! - stray leakage is sufficient. Similarly, you should be able to hear the BFO at about 4000 Khz on your main station receiver. If not, these steps point to a problem with U3 or its associated BFO components (Y4 and C17-18).

• Transmitter

Be sure a load is connected anytime you're troubleshooting the transmitter.

• Verify that the keying switch Q3 supplies 12V to the transmit mixer (U5) and Buffer/driver (Q4,Q5) stages when the "Key" input is grounded. Note that the voltage reading at pin 8 of U5 should be 7.1 - 7.9 volts. No-voltage during key-down suggests that Q3 is bad or that D11 is installed backwards.

• Touching a screwdriver to Q6's case (collector) should yield a distinct (key-down) increase in signal received on your "big-rig" receiver. If not, suspect Q6.

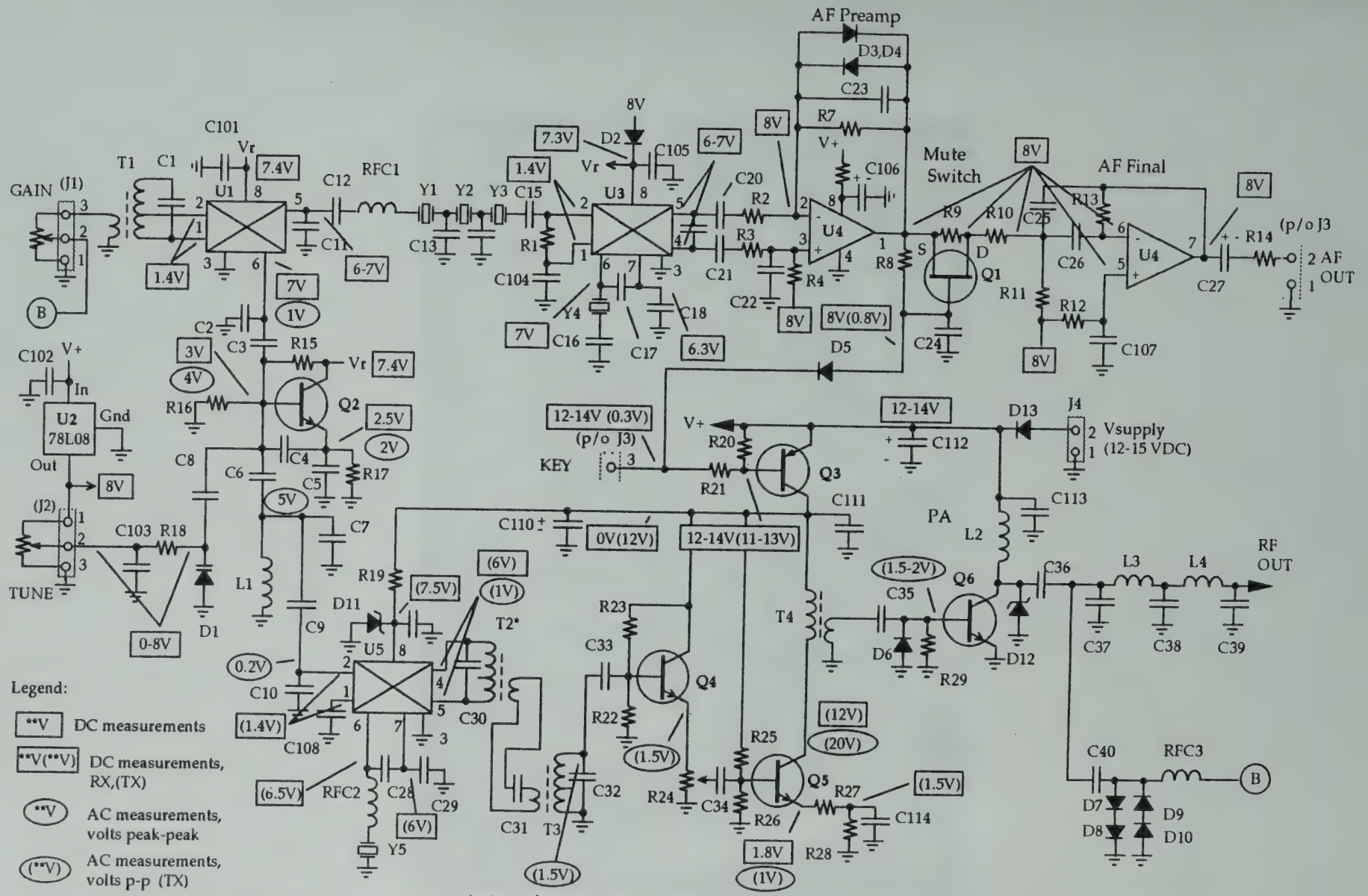
If you want to change the sidetone pitch, increasing the value of C29 raises the sidetone pitch (and Tx offset) and decreasing that cap lowers it.

Don't panic!

. . . and don't smash your "SW-40+" against a wall! If all else fails, contact me for further technical support:

Dave Benson, NN1G
80 East Robbins Ave.
Newington CT 06111
(860-667-3536)
e-mail: bensondj@aol.com

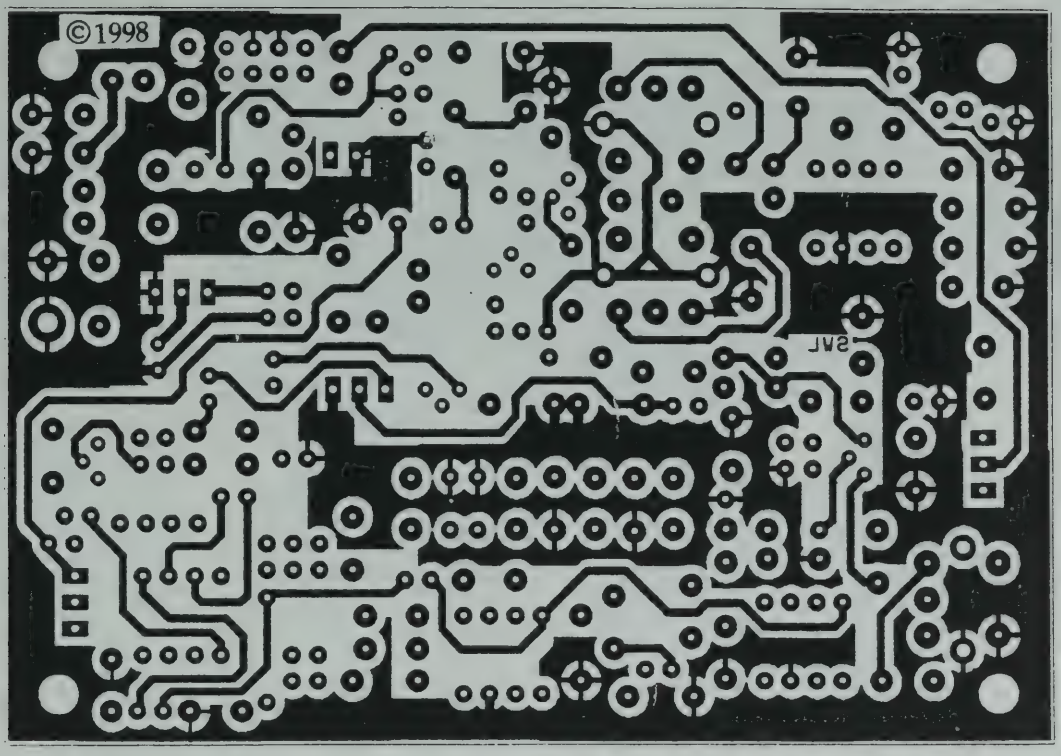
Troubleshooting / Alignment is available for a $25 fee. The unit will be returned to you in working condition and will include a troubleshooting report. Price includes return shipping.



Troubleshooting the "SW-XX+" Transceiver

SMALL WONDER LABS™

3/10/98



Bottom (solder) layer view

A Single-Board Superhet QRP Transceiver for 40 or 30 Meters

Superhet performance in a small, inexpensive package—just the thing for traveling or low-profile operating.

By Dave Benson, NN1G
80 E Robbins Ave
Newington, CT 06111

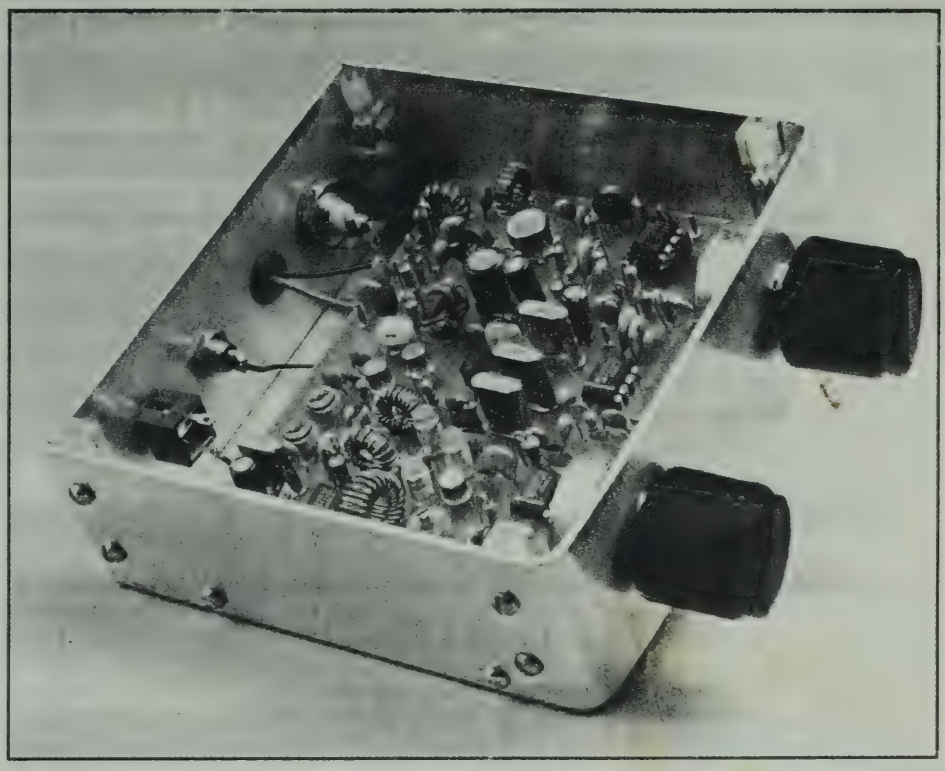


Figure 1—Mounted in an enclosure, the 30 and 40-meter transceivers make handy portable rigs.

I suspect it's been a while since most of us have truly understood what goes on behind the front panel of our transceivers. Perhaps the dazzling array of features at our disposal mutes the recognition of elegant simplicity as a design philosphy. With all this convenience at hand, why would anyone wish to build his own gear? Because there's a certain satisfaction to being able to say "I did it myself." You can't get that satisfaction in a box!

This article describes the "40-40," a single-board superhet transceiver project designed with ease of construction in mind. This design was initially developed under the auspices of the New England QRP (NE-QRP) club for use as a club project (see the sidebar for details). Far from being a "one-of-a-kind" special, nearly 200 of these transceivers have been built to date! Members of the Boston Amateur Radio Club have also built about a dozen of these transceivers.

NE-QRP emphasizes homebrewing to encourage member participation. We recognize that this isn't everyone's cup of tea, though, and sought easily reproduceable designs. We insisted that the product be as simple as possible (consistent with good performance), be modestly priced, and offer the builder a high probability of success. This project's nickname is symbolic of its original band coverage (40 meters) and cost to members ($40).

With these goals in mind, the club settled on a "bare-bones" superhet transceiver board. When you get right down to it, a workable superhet design needn't be more complex than a good direct-conversion (D-C) transceiver. This approach pays off in relative freedom from received QRM and a stable transmitted signal. We did cut several corners to hold cost and complexity to a minimum:

• We deleted the receiver's intermediate-frequency (IF) amplifier to save current drain and shave the parts count. As a result, standby (quiet-signal) current for this transceiver is only 21 mA! This approach has been described by DeMaw previously[1] and reflects our club's interest in solar/battery operation. Consequently, this design is intended for headphone use only. It provides more-than-adequate audio levels with a good set of low-impedance phones.

• We left out RIT (receiver incremental tuning) for much the same reason. The result of this minimalist philosophy is a radio with only two controls: gain and tuning! The design lends itself to adding RIT as an outboard option.

The design efforts resulted in a single printed-circuit board measuring only 2.8 × 4 inches lending itself readily to packaging in any of a number of commercial enclosures (Figure 1). Packaged as a complete board kit, the offering included the PC-board, all on-board parts and wire for toroid winding, and a comprehensive instruction manual.[2] Builders provided the enclosure, assembly labor, and controls and connectors. These last items are all available from Radio Shack, so rounding up the necessary parts to complete the project needn't be an exercise in frustration! Let's take the 25-cent tour through the design:

So How's It Work?

Refer to Figure 1 for the following discussion. Although this text describes the 40-meter version, the 30-meter version is identical except for the choice of IF (8.0 MHz) and local oscillator (2.1 MHz). The receiver RF input is applied to U1 through T1, C1, and C2, which provide a bandpass filter tuned to the band in use. This circuitry attenuates out-of-band sig-

[1]Notes appear on page 41.

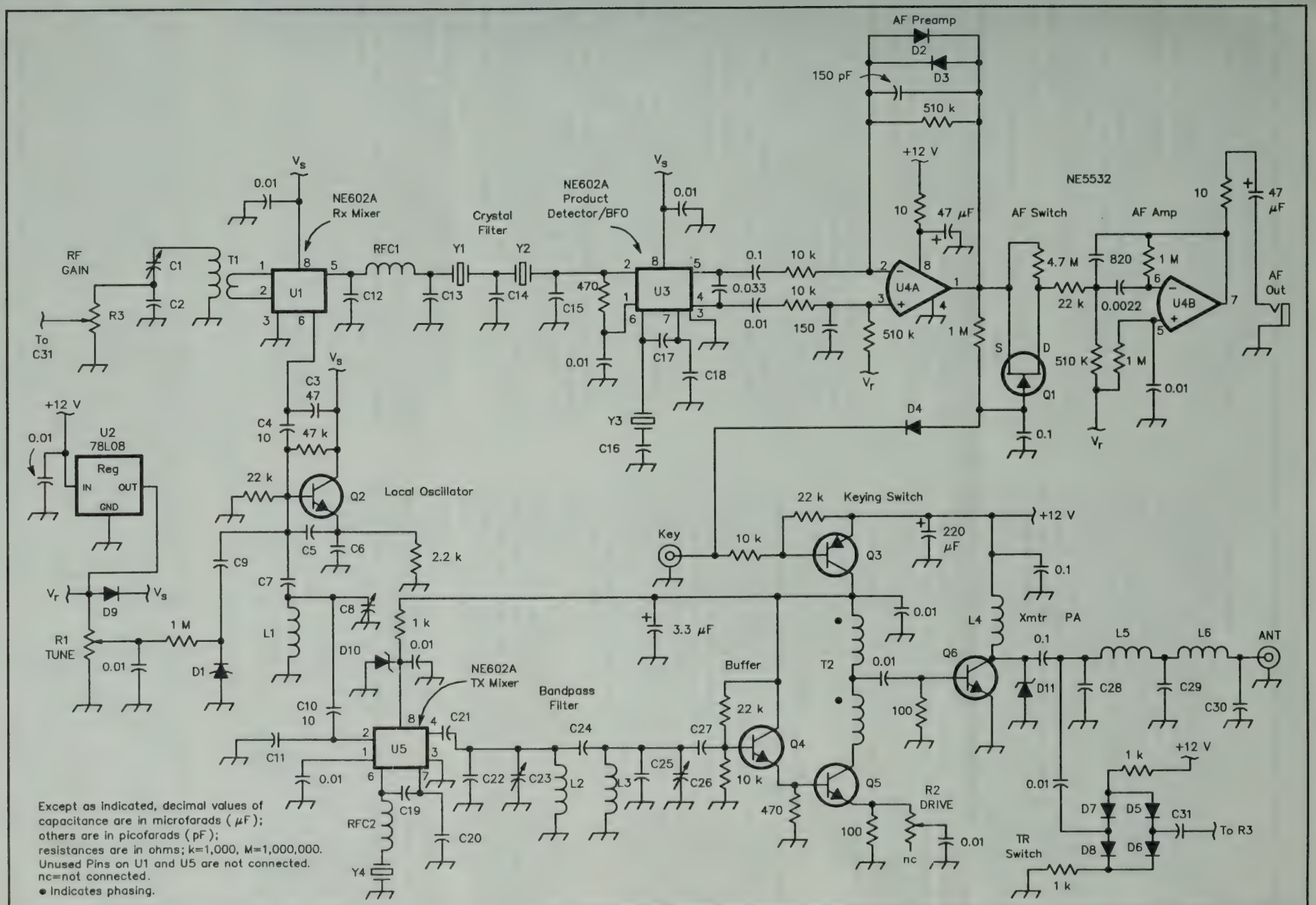


Figure 2—Schematic diagram of the transceivers. Table 1 is the parts list. See the text for additional details. Etched circuit boards and kits of board-mounted parts are available. See Note 2.

Anatomy Of A Club Homebrew Project

A well-organized project can attract new members to your club, and entice old members to return to meetings. Here are some suggestions to help other clubs repeat the success of the 40-40:

• Identify Your Goals

Your organization probably has a central theme, whether it be Public Service, DXing or any of the many specialties that draw us together. By focusing on your needs and interests, your group can identify that perfect building project to serve as a focal point for boosting club camaraderie.

• Choose Wisely

A review of the literature will turn up candidate kit projects suited to your group's needs. The project's complexity, of course, hinges on the skill level of the membership and the availability of technical guidance. For the club lucky enough to boast an experienced builder, you might even consider "rolling your own." This will be especially true of the specialty groups (eg, ATV, VHF) who may be more construction-oriented to begin with.

• Seek the Guru

If you're going to develop your own project, you need a "Guru"! This doesn't imply a doctorate in engineering with a labful of gear, but your candidate should have a track record of successful homebrew work. This person understands the pitfalls inherent in designing an item that can be duplicated, not just once, but dozens of times! These folks aren't as rare as you might think—you might be surprised at the depth of experience among your club's ranks!

• The Project Leader

It's imperative to establish a key player to "pull it together." Unless your guru enjoys bringing an idea to production, this is a function distinct from the technical role. The project leader establishes and maintains a schedule, orders and receives parts, and enlists the aid of other necessary helpers.

A few words about scheduling: Much as we all dislike deadlines, once you've advertised a schedule for getting a project on the street, stick with it! The project leader needs to identify milestones early-on for such elements as completing tests, ordering parts and lining up help. Remember that Murphy doesn't take vacations, so allow extra time for parts orders to arrive!

• "Beta" Testing

Whether the project is a commercial kit or your own handiwork, you want to be assured that the kit goes together smoothly. You need to discover schematic errors or parts kitting shortages *before* your entire group warms up their soldering irons! You need one or more volunteers who build up the project solely from the furnished kit materials and instructions. If you have a "Guru," leave him out of this! He knows too much, and you're better off having people more representative of the average club member. This assures that the designer didn't overlook anything or leave crucial information out of the document package.

• The "Parts Team"

If you're purchasing a kit, this step is easy—send money to your chosen supplier and he sends you pre-packaged kits in return. You may expect the occasional missing, defective, or "I plugged it in backwards" parts problems to occur. If you're ordering in quantity, consider buying a spare from which to cannibalize parts. This avoids the inevitable delays involved in calling the supplier and waiting for replacements to arrive.

If it's your club's own brainchild, though, you've got a little more work ahead! The project leader needs several volunteers who can bag parts, reproduce and staple instruction sheets, etc. Once all the parts are in hand, the "kitting party" becomes part work and part social occasion. If your club is far-flung geographically, you may be able to find several willing members within reasonable driving distance to serve this function.

Allocate at least a half-day, preferably on a weekend, to get all the kitting done in one session. One suggestion: You don't want to be kitting parts while you're fatigued, so avoid late evenings. It takes a surprising amount of concentration to count out parts from their containers (we used cereal bowls). Interruptions should also be kept to a minimum—take the phone off the hook and turn off the H-Ts!

• Spreading the Word

Be sure to keep the membership apprised of the project's status. This helps maintain a high level of interest and anticipation in the outcome, and if snags arise, you may get additional help by keeping people informed. Your club's newsletter is the ideal vehicle for disseminating this information. The project leader should be working closely with the newsletter's editor to get the message across and to assure sufficient publicity. One other tip—when you're ready to release the project to the membership, make sure the point of contact for handling orders, collecting checks, etc is clearly identified. This should be one person, not a committee. Nothing beats confusion as a source of unnecessary work!

• Elmers

Every club has Elmers—experienced people willing to share their time and expertise with others. Make use of them! Provide your members with names of a couple of experienced hams who can answer questions and suggest troubleshooting tips if necessary. There's nothing like a "mentor" when you need assistance!

• Follow-Up

Put that new project to work! This step is critical to maintaining member interest and to ensure that the new gizmo doesn't sit unused on the back of the workbench! If appropriate to the project, your club might sponsor an operating event featuring the completed items. A "trouble-shooting session" is also a good idea for local organizations. This lends members the impetus to give their work the "smoke test." And finally, follow up your club's results by publishing summaries in your newsletter. Don't forget to keep your ARRL Section Manager informed, so that your club's good name shares its rightful spot in the limelight!

nals to minimize the risk of overloading U1. U1 converts the RF input to the IF of 4.000 MHz and provides about 13 dB of gain. The L network (C12 and RFC1) following the mixer matches that stage's output impedance to the crystal filter's design value.

The crystal filter itself uses only two crystals instead of the usual four. This works well because of the choice of a low intermediate frequency. (The 8-MHz IF used for the 30-meter version is somewhat broader, but the result is still usable.) Loss through the filter is less than 2 dB, and with the component values shown, the –6 dB bandwidth is about 500 Hz. Despite the filter's low parts count, performance is adequate when combined with the AF section's selectivity. The unwanted sideband image is down about 45 dB at the audio chain's 800-Hz peak response frequency.

The filter output is terminated in a 470-Ω resistor at the input to U3, the product-detector stage. U3 converts the 4.0-MHz IF signal to audio and contributes another 13 dB of gain. BFO crystal Y3 has been selected to match the IF filter frequency, so there's no BFO frequency trimming needed. The 0.033-µF capacitor across pins 4 and 5 of U3 provides the first measure of audio low-pass filtering.

The two sections of U4 each provide roughly 30 dB of amplification. The first section is configured as a differential amplifier to make use of U3's differential output, and rolls off the audio response

See Note 2.

Table 1
Parts List For The Transceivers

Designation *(See Figure 2)*	*40-Meter Version*	*30-Meter Version*
C1, C23, C26	8 to 70-pF, 6-mm trimmer	8 to 70 pF, 6-mm trimmer
C2	220 pF	150 pF
C3	47 pF	47 pF
C4	10 pF	10 pF
C5 to C7	0.0022 µF, 5% Polystyrene, radial lead	0.0047 µF, 5%, Polystyrene, radial lead
C8	2 to 27 pF (Digi-Key SG3004)	2 to 27 pF (Digi-Key SG3004)
C9	68 pF	150 pF
C10	10 pF	10 pF
C11	220 pF	220 pF
C12	47 pF	22 pF
C13	150 pF, 5%	270 pF, 5%
C14	150 pF, 5%	270 pF, 5%
C15	150 pF, 5%	270 pF, 5%
C16	68 pF	none (replace with jumper)
C17	47 pF	68 pF
C18	47 pF	150 pF, 5%
C19	47 pF	47 pF
C20	150 pF	220 pF
C21	10 pF	10 pF
C22	150 pF, 5%	150 pF, 5%
C24	5 pF	5 pF
C25	150 pF, 5%	150 pF, 5%
C27	47 pF	47 pF
C28	470 pF	330 pF
C29	0.001 µF	680 pF
C30	470 pF	330 pF
C31	68 pF	47 pF
L1	3.65 µH (27 t #22 on T-50-2 toroid)	3.65 µH (27 t #22 on T-50-2 toroid)
L2, L3	2.5 µH (25 t #26 on T-37-2 toroid)	1.2 µH (20 t #26 on T-37-6 toroid)
L4	10 µH (5 t #22 on FT-37-43 toroid)	7 µH (4 t #22 on FT-37-43 toroid)
L5,L6	1.0 µH (16 t on T-37-2 toroid)	0.68 µH (15 t #26 on T-37-6 toroid)
RFC1	22-µH epoxy RF choke	10-µH epoxy RF choke
RFC2	22-µH epoxy RF ckoke	4.7-µH epoxy RF choke
T1	Primary 16 t #26; secondary 4 t on FT-37-61 toroid	Primary, 11 t #26; secondary 6 t on FT-37-61 toroid
Y1 to Y4	4.000 MHz (see text)	8.000 MHz (see text)
(Remaining parts are identical for both bands)		
D1	MV1662 Varicap diode	
D2 to D9	1N4148 or 1N914	
D10	7.5-V Zener, 0.5 W, 5% (1N5236 or equiv.)	
D11	33-V Zener, 0.5 W, 5% (1N5257 or equiv.)	
R1	100-kΩ linear-taper pot	
R2	200-Ω Cermet trimmer pot (Digi-Key 36C22)	
R3	5-kΩ linear-taper pot	
Q1	2N5486 (2N5485 or MPF102 substitutes)	
Q2, Q4, Q5	2N2222A metal	
Q3	2N3906 or equivalent PNP GP Switch	
Q6	2N3553 (MRF-237 substitute)	
T2	4 bifilar turns on FT-37-43 toroid (use 3-inch piece of two-conductor ribbon cable)	
U1, U3, U5	NE602A(N) Signetics mixer/oscillator IC	
U2	78L08 voltage regulator IC	
U4	NE5532	

Notes
Small-value capacitors are 10% tolerance ceramic disc, unless otherwise noted.
Decoupling capacitors are ±20% ceramic or monolithic types.
Electrolytic capacitors are minimum 16 V dc.
All resistors are 1/4-W, 5% tolerance.

above 1.5 kHz. Diodes D2 and D3 limit the audio swing during transmitter key-down to reasonable values. Without these diodes, this stage saturates and upsets the operation of the FET switch section that follows.

The AF mute function is the familiar series-FET switch popularized by W7EL.[3] Despite its relative simplicity, it's hard to beat this circuit for click-free audio switching. In the key-up condition the FET is zero-biased and acts like a resistance of several hundred ohms. In the key-down condition the FET is in cutoff (because the gate is now 7 to 8 V below the source) and acts like an open-circuit, preventing audio from getting to U4B, the audio final stage. The 4.7-MΩ resistor across the FET serves to "leak" a sample of the received signal during key-down, and thus provides a built-in sidetone.

The audio final stage is configured as a bandpass filter centered at 800 Hz. The high gain of the two NE5532 stages allows a design with no IF amplifier stage. The audio output level is adequate to drive headphones, but it won't cut the mustard for loudspeaker applications. The AF-output stage is internally overcurrent limited on loud signals, to provide ready-made ear protection. (In this respect, it accomplishes what you'd want an AGC for anyway.) If you're interested in saving a few milliamperes on receive, either TL072 or an MC1458 may be substituted, although at reduced maximum AF output levels. Use good quality low-impedance headphones for best results. Walkman headphones are fine, but remember—you get what you pay for. The $3 cheap imitations are distinctly inferior!

Diodes D5 through D8 and associated components provide full break-in (QSK), to eliminate the annoyance of a switching relay. This "bridge" circuit presents a low resistance to small signals (in the receive mode), yet limits the receiver input voltage swing during key-down to several volts peak-to-peak.

The local oscillator uses the familiar Colpitts configuration. Polystyrene capacitors aren't the usual candidate of choice when used alone in a VFO design, but I used them here because they're compact and available in 5%-tolerance values. The resulting temperature stability is more than adequate at 3 MHz. Coverage is about 40 kHz on 40 meters and 25 to 30 kHz on 30 meters. Both transceivers cover the parts of the subbands most used by QRPers, and allow use of a single-turn tuning pot. If you want broader frequency coverage, the value of C9 may be increased. Use NP0 or silver-mica capacitors if you experiment with this circuit. The design uses a varicap tuning diode for tuning. While a smooth ball-bearing tuning capacitor and vernier reduction drive are the preferred approach, that choice drives up the cost and mechanical complexity of a transceiver considerably.

The transmitter portion of this design consists of mixer/oscillator U5, driver stages Q4 and Q5, and the power amplifier (PA) stage, Q6. The output power is about 1.5 W and a drive control (R2) at the emitter of Q5 sets the output level. The L-C components between U5 and Q4 form a bandpass filter that serves to filter the relatively complex waveform at U5's output into a clean sine wave.

Performance Summary

Testing conducted in the ARRL La confirmed that this design met FCC requirements for transmitter spectral purity. A harmonics were down more than 34 d from the carrier for the 40-meter versi and 32 dB for the 30-meter version. Spur ous outputs were down at least 35 dB. Whi additional filtering would improve the cha

acteristics, these values meet present FCC requirements. Transmitted-waveform rise and fall times are 1 to 2 milliseconds. The receiver performance was also evaluated. The two-tone dynamic range (90 dB) and blocking dynamic range (115 dB) are fine for a receiver of this simplicity.

Construction

Table 1 lists parts for both versions of the transceiver. A few tips on constructing this project are in order. Although a printed-circuit board is available, there's nothing to prevent you from duplicating this design using "dead-bug" or "ugly" construction. Remember to keep all leads and connections short and direct if you're employing this approach.

Soldering

Use a small (25-W) iron (such as a Radio Shack 64-2070) and keep the tip clean. Use a moistened sponge or paper towel to clean the tip periodically as you work. Apply only as much heat as is needed to get a good joint. The use of a high-wattage soldering gun is not recommended, as it will tend to lift traces off the board.

Unsoldering

Sooner or later, you're going to need to remove a part installed in the wrong location, or perhaps pull a part for troubleshooting purposes. There's an easy way: get yourself a roll of desoldering braid (Radio Shack 64-2090B). Lay the end of the braid down on the joint to be cleaned and press the soldering iron tip over the braid. Within a second or so, you'll see the braid begin to wick up solder from the joint. Remove the braid and reapply a new section as needed until the joint is clean. This is good stuff—with care, it's possible to remove ICs from the board without damaging them.

Checking Your Work

Get into the habit of checking your work each time you put down the soldering iron. It's much easier and ultimately less frustrating to find solder bridges sooner rather than later.

If you're rolling your own version of this transceiver from scratch, select the crystals (Y1 through Y4) for identical frequency characteristics. The design makes uses of readily available microprocessor crystals to keep the cost low. A batch of 8 to 10 of these should yield four crystals that oscillate within 50 to 100 Hz of each other, and the most closely grouped crystals are the ones you want! A "what-have-you" test oscillator may be kluged up on a scrap of circuit-board material. Its characteristics are noncritical, as you're interested in frequency consistency rather than absolute accuracy. A frequency counter or main-station receiver is used to perform this grading "by the numbers" or "by ear," respectively. Incidentally, the choice of 4.000 MHz as the 40-meter IF yields a strong "birdy" at 7.000 MHz. If your plans include the use of the extreme low end of the band, 4.032-MHz crystals are a better choice.

Alignment

Alignment of this little rig is a piece of cake. For test equipment, you'll need a main-station rig and SWR meter or wattmeter. Here's how:

Receiver

• Double-check your power supply polarity *before* you apply power!

• Apply dc power and connect a pair of headphones to the receiver AF output.

• Set tuning pot R1 to full counterclockwise (0 V on R1's center terminal). Using your main-station rig (at minimum power into a dummy load, please!), transmit a string of dots at the frequency you desire for the low end of your band coverage. Adjust trimmer cap C8 until you hear your main-station rig's transmitted signal. You may need to remove a turn from L1 to get the tuning range up into the 40-meter band. If the band coverage is too high in frequency, squeeze the turns on L1 together to reduce the operating frequency.

• Connect a matched antenna. Using a *nonmetallic* tuning tool, peak C1 for maximum signal (or noise). If you don't have one of these tools, you can make one from a narrow strip of PC board material with the tip filed down to fit the slot in the tuning cap. The use of an insulated tool is important because body capacity will make adjustment difficult otherwise. Once this step is complete, background noise will be noticeably higher with an antenna connected than without.

Transmitter

• Set drive adjustment pot R2 to its full counterclockwise position.

• Add a clip lead to the case (collector) of Q5 to serve as a short antenna. (Leave the other end of the clip lead unconnected.) Ground the "key" input and tune in your transmitted signal on your "big rig" receiver. Adjust trimmers C23 and C26 for maximum indicated signal on your receiver's S-meter. The capacitors will be somewhat interactive, so alternate between the two as you tune for maximum output.

Remove the clip lead. Connect the RF output to a wattmeter. If you lack this luxury, you can use your SWR meter in the **FORWARD** position, connected to a dummy load. Adjust R2 as needed for 1.5 W key-down power into a dummy load or the test circuit. More is *not* better—you'll coax a little more power out at the expense of efficiency!

That's it! You're on the air. Feedback to date from other builders has been highly favorable. You might be surprised at what you can work on either 40 or 30 meters with only a watt or two. I've had the pleasure of ragchewing with stations from all over the US and have worked about a half-dozen European countries with the 40-meter version alone.

Acknowledgements

Special thanks are in order to Jim Fitton, W1FMR, for his guidance; to Paul Kranz, W1CFI; Wayne Burdick, N6KR; and others for design suggestions and other support. This rig was first described in the April 1994 issue of *72*, the newsletter of the New England QRP Club.

Notes

[1] D. DeMaw, "A Four-Stage 75-Meter SSB Superhet," *QST*, May 1989, pp 25-28.

[2] Kits of parts for the 40-40 and 30-40 are available for $50 postpaid from Small Wonder Labs, 80 East Robbins Ave, Newington, CT 06111.

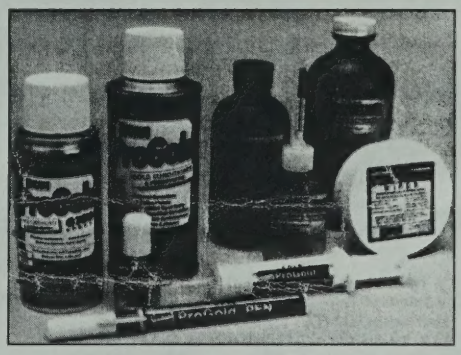
Be sure to specify either the 40 or 30-meter version. Includes selected crystals, all on-board parts, wire for toroids and manual. Allow three weeks for delivery. (The ARRL and *QST* in no way warrant this offer.)

Circuit boards (only) for this project are available for $6 (plus $1.50 postage) from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118.

Dan's Small Parts and Kits (1935 S 3rd West No. 1, Missoula, MT 59801) carries many of the parts needed for this project. Remaining items may be obtained from Jameco, Mouser Electronics, and Digi-Key Corp. See the List of Suppliers in the ARRL *Handbook* for more information.

[3] R. Llewellyn, "An Optimized QRP Transceiver for 7 MHz," *QST*, Aug 1980, pp 14-19 (an updated version of this project appears in the 1994 *ARRL Handbook*). QST

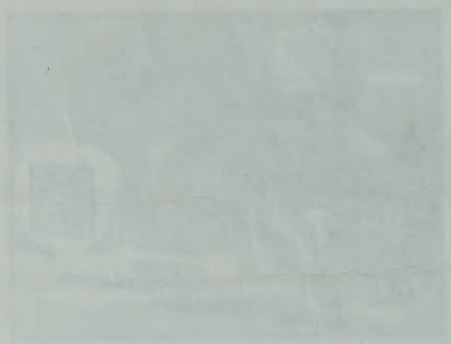
New Products



PROGOLD CONTACT CLEANER/ ENHANCER

◊ Caig Laboratories' ProGold contact and connector cleaner/enhancer/conditioner is now available in five packages. ProGold deoxidizes and cleans surface contamination on electrical connectors and contacts, and actually penetrates plated surfaces and bonds molecularly to the base metal. This bonding action, according to the manufacturer, is unique to ProGold.

Treating contacts and connectors can reduce arcing, RFI, wear, abrasion, and intermittent connections. Use it on switch contacts, connectors, edge cards, plugs, sockets, relays—even on bare circuit boards.

ProGold is available in spray, liquid, precision dispenser, wipes and pen applicators. Contact Caig Laboratories Inc, 16744 West Bernardo Dr, San Diego, CA 92127; tel 800-CAIG-123, fax 619-451-2799. QST

New Products